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ABSTRACT

The data compression aspect of 20th century science is evident in the "mass action" concept of brain function embodied in the "g" model of intelligence and academic tests. This paper sketches the history of the devolution of the "g" model into multifactored intelligences, contrasts dynamic process versus static product assessment, and discusses the effects of process assessment on measurement theory. An alternative neurocognitive processing assessment, as opposed to the traditional IQ content driven assessment, is applied to the assessment of children in the academic sphere. The functional utility of this approach, focused process assessment, is shown through discussions of previous studies related to diagnosis in learning disabilities, the relationship to school learning analysis of complex processes like reading comprehension, the prediction of future academic achievement, the development of specific treatment plans, and effective curriculum development. Using the focused process assessment model rather than the data compression model of the last century will lead to an entirely different diagnostic system. (Contains 89 references.) (SLD)

# Focused

# Process

# Assessment:

# The New

# Measurement

# for the

# New Millennium





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The New Measurement for the New Millennium

**Abstract**

The 20th century is noted for the development of a scientific approach to social, psychological, and philosophical problems. The major contribution of this scientific endeavor has been measurement techniques to compress of vast amounts of data into a palatable size. Nowhere is data compression more evident than in "Mass Action" concept of brain function embodied in the 'g' model of intelligence and academic tests. On the other hand the course of advancement in science arises from the controlled analysis of hitherto seemingly unitary concepts. We sketch the history of the devolvement of the 'g' model into multifactored intelligences, contrast dynamic process vs static product assessment, discuss the effects of process assessment on measurement theory. We apply an alternative neurocognitive processing assessment as opposed to the traditional IQ content driven assessment of children within the academic sphere. We demonstrate the functional utility of the neurocognitive process approach to diagnosis in learning disabilities, relationship to school learning analysis of complex processes like reading comprehension, predication of future academic achievement, the development of specific treatment plans and application to effective curriculum development,

**Introduction**

Twentieth century psychology will be known as the century of the IQ test. Nothing has so clearly marked the science of psychology for most of the last hundred years as the unchallenged supremacy of the concept of 'g', a single omnibus score for the measurement of all mankind's cognitive faculties. The social sciences in particular have thrived on the data compression model describing multiple data points by their collective mean and standard deviation. In education marking progress by the "grade equivalent" or percentile rank in reading is simply another facet of the data compression 'g' model applied to the classroom.

It was a comment by Oscar Buros, some 25 years ago that started all this in my mind. He said " If two youngsters take a test, one in first grade and one in twelfth, and they both scored at the 6th grade level, nothing can convince me that they arrived at that score in the same way. In the 1970's this was an astonishingly radical statement. As a hard-shelled data compression measurement person I felt this almost an act of betrayal, and, by one of the most authoritative figures in measurement of the 20th century.

At first, I thought, well that's logical they would probably answer different questions correctly. After much rethinking over several years I saw how trivial my original response was. What Dr. Buros was really saying was that these two minds were working differently, and that the test had done nothing to explore these differences, further, by encapsulating their reading abilities into a single score we have hidden even the fact that they are different individuals.

**A Measurement theory on the twentieth century: cynical overview of the past century**

Measurement theory during the twentieth century has been primarily concerned with data compression, that is squeezing a large number of data points into a single number which is readily understood. It is the data compression model which underlies Dr. Buros comments. By compressing a large number of data points we have lost, indeed have not even searched for, the individual or diagnostic information critical to formulating treatment plans. In essence that reading grade score was not about the child, but about that child's place in his class or in the national norm.

Let us put this within an historical context.

During 19th century and before, "truth" was established largely by authority, revelation, testimony, logic, experience and anecdote. The 20th century saw first major break away from these time honored forms of "truth" seeking in the form of the application of scientific method to measurement of social phenomena.

In late 1890's that the first glimmerings of scientific method arose in from Galton, from Wundt's laboratory in Germany, and with William James, James McKeen Cattell and E.L. Thorndike in the US, and in France with Binet and Simon.

Across this same era, while neurologists like Broca, (1856) Penfield, & Rasmussen, (1950) Posner, Petersen, & Fox, (1988) and Wernicke, (1908) were beginning to localize neurocognitive functions, the concept of "Mass-Action" intellectual functioning was being promulgated by psychologists, notably Spearman, (1903), Lashley, (1929) and Lashley & Clark, (1946) who had an abstract notion of the mind working as a singular unit, "mass action" or general or global intelligence, which Spearman termed 'g'. From a logical point of view it is not difficult to see why this concept was so captivating. This global position is probably responsible for much of the popularity of psychology today. Compressed data is much easier to understand, and much simpler to talk about in layman's terms. It is our limited human mental capacities (working memory, not intelligence) force us to reduce what is inordinately complex and dynamic into such simple static terms. This simplification by globalization has wide appeal in intellectual circles and numerous thinkers have sought to compress human endeavors into an all encompassing single or to a small number of concepts. Indeed, the popularity of psychology today is attributable to these over simplifications which have appeared to make the complicated human brain appear understandable to the layman.

The global tradition then, has had a stabilizing influence on thought. While it increases comprehensibility, it also induces viewing individuals as members of artificial groups or classes, and influences thought about members of these classes in the direction of sameness. As Dr. Buros was pointing out this oversimplification simply avoids or covers-up a wide variety of important differences between individuals.

**The Binet-Simon Intellectual Stream:**

The Binet-Simon test (1908), according to Sattler (1992) was developed as a selection device which would determine which children it would be profitable to educate further. Through long testing and item tryouts Binet generated a developmental sequence of items commonly answered by individuals at each age level. Within one age level there were a variety of items, testlets, if you will: an information item or two, one or two vocabulary items a pictorial or manipulative item and so on. By relating the number of testlets passed to the age of the child, a single score, the intelligence quotient (IQ) could be used as a predictor of future success in school. It was this IQ notion that is most commonly identified with the data compression 'g' model of mass action of the brain.

Advocates of Spearman's 'g' concept clutched at the Binet Simon test as a demonstration of their concept, and the simple discriminatory tool, designed to cut students from the academic track in France came to America to become the arbiter of all mental abilities.

**1920's, Beginning measurement fever**

From Terman's (1916) introduction of the Stanford Binet through WW I and the need to predict intelligent soldiers confidence in the "Scientific" measurement movement grew in such force and vigor that during the 1920's and through the 1940's tests sprouted like tulips in the spring. Most of these fell by the wayside (some to be reinvented as neuropsychological instruments). Those that survived were mostly 'g' model data compression tools and developed a single score describing reading, spelling, arithmetic and or personality.

The Terman adaptations of the Binet test became the gold standard against which all other American instruments were measured until the late 1970's when prodded by the measurement bias provisions of PL 94-142 it became evident that, the Stanford-Binet, along with the Rorschach, the Bender Gestalt, the Thematic Apperception Test and a number of other old faithfuls had no, or inadequate reliabilities available (Ysseldyke, et al., 1980). It was correctly argued that use of these instruments was subject to unknown amounts of bias and error, and therefore inappropriate for individual pupil planning. Publication of this fact completed the transition to the Wechsler instruments as the standard for intelligence assessment.

**The Wechsler Devolvement: Improvements on the Binet-Simon approach:**

The effect of the Wechsler tests on the nature of human cognition has been more subtle than that of the Binet-Terman model. Wechsler, while developing the Wechsler-Bellevue scale (Wechsler, 1939) had tried out somewhere over 200 tests. Like Binet, Wechsler simply tried tests until he found ones that appeared to have some developmental relevance. Parenthetically, it is interesting to note that Wechsler's item selection appeared to be very similar to the many of the testlets of Binet, who applied a similar procedure nearly half a century before.

For Wechsler himself, the tests were primarily standard clinical observation protocols. According to Kaufman, (1994), Wechsler was a consummate clinician and needed only a few items to make his analysis, He was vehemently opposed to removing items of clinical significance to substitute politically correct items in the later editions of his tests. Unfortunately this same clinical approach lead to a wider range of items within a subtest than might be the case with a more empirical test construction approach.

Had it not been for the compression of this observation schedule into a numeric form the Wechsler tests might have been just one of a hundred other similar observation protocols. It is the overlay of the data compression measurement which made the Wechsler tests accessible to those of us with lesser clinical skills. Whatever the reality, Wechsler made a number of significant contributions to testing intelligence.

**Subtests:**

The subtest was perhaps Wechsler's greatest contribution to the science of psychology. Once Wechsler collected of all the little Binet type testlets into the developmental sequence of similar probes within each subtest, the verbal and performance aspects which were hidden within the Binet- Terman tests became patently obvious. On the one hand Wechsler showed us that, intelligence was the synthesis of a number of elements and further, intelligence could be analyzed into these components These subtests clarified the basic structure of the instrument and of what an intelligence test measured.

**Verbal and Performance Intelligence**

It was little noted that Wechsler's heuristic factors, Verbal and Performance IQ were the first empirical step in the scientific analysis of 'g' in the Binet stream. These heuristics have been generally supported by later factor analyses. Not only did the performance and verbal scales produce a vast literature concerning the meaning of each and their differences but since a metric was developed for the subscales, they too have been favorites for generating interpretative schemes. In the data compression model the subscales were never intended for interpretation, none the less the separate standard scores for the various subscales are tempting for analysis. The major problems with subscale of interpretations are two, low reliability and complex validity interpretation.

First subtest the reliabilities are much too low for individual interpretation. The generally accepted minimum reliability for an acceptable level of error for individual diagnosis and treatment design is $r_{tt} = .90$ or higher. ( Anastasi, 1980; Guilford, 1953; Nunnally, 1970; Ysseldyke, et al., 1980) The median reliability of the WISC-III subtests is .82. When compared with a validity instrument of like reliability, there is more than 50% error variance entering into the interpretation. These low reliabilities indicate a high probability of interpretative error in diagnosis and an increased probability of a faulty treatment plan.

Further, data compression subscales are broadly constructed to capture as much of 'g' as possible. This breadth of the subtests leads to multiple interpretations. A single subscale may have as many as a dozen possible interpretations to choose from (Kaufman, 1994; Sattler, 1992). Thus it is the clinician's intuition, and not a reliable, valid metric, that forms the decision. All in all, this places subscale interpretation on a par with the Ouija board. Poor decisions, based upon loose evidence from this hollow metric, and effecting children's lives, are all to common.

Leaving the foibles of subscale analysis for the moment; the important fact that Wechsler's model demonstrated was that there was intellectual profit to be had from the analysis of 'g'. Since the Wechsler tests, much of the intelligence literature has revolved around methods partitioning 'g' and getting more reliable and valid information from the tests. There has been a wide variety of approaches to this analysis, well beyond our scope here. These range from the development of various heuristic factors (Bannatyne, 1969) to numerous profiles and scale combinations with attempts to match them with various concepts of human cognition (Kaufman, 1994; Sattler, 1992). These attempts are generally hampered by the interpretative breadth of the subscales. Each subscale may have as many as a dozen possible interpretations and when combined with others into heuristic factors, the same reliable subscale combinations may have several very different interpretations depending upon the point of view with which it is approached.

Perhaps presently, the most important of these approaches is the factor analytic approach crystalline (Gc) and fluid (Gf) intelligence of Cattell and Horn, (1978). Recently McGrew (1993) has pointed out that the Gc-Gf approach of intelligence has a potential for considerable improvement in assessment practices in school psychology. McGrew says "building of the work of Cattell, Horn's (1991) extensive program Gf-Gc it research has identified nine broad ability. -- Fluid Intelligence,(Gf); Crystallized Intelligence,(Gc) Short-Term Acquisition and Retrieval,(STR), which may be divided into Auditory (Ga) and Visual (Gv); Cognitive Processing Speed, Correct Decision Speed and Quantitative Knowledge. This type analysis is largely been limited to the Binet stream and is limited by the circumscribed information contained in the Binet approach. This approach has largely reached a dead end (Carroll, 1993)

There have been alternatives of course, the most successful is the Woodcock/Johnson. The original Woodcock/Johnson (1976) appeared to be developed on a more classical dynamic processing model, with many highly reliable subscales assessing a verbal learning, generalization/discrimination, analysis/synthesis. This model which showed great potential for developing interventions in cognitive processing. Unfortunately instead of exploiting its unique processing approach the later Woodcock/Johnson (1976) Woodcock (1989, 1991) has seen fit to wedge his instrument into the Cattell, Horn, (1978, 1991) Gc-Gf analysis of the Binet stream.

A second alternative with much promise is the Das-Nagliari Cognitive Assessment System (1994, 1996) which is based on a model derived from Luria's (1966, 1973) concept of simultaneous and successive processing and assesses such variables as planning and attention of considerable interest in schools. This model, along with the Woodcock/Johnson avoids dependence upon content and declarative information and in turn is less likely to be biased by culture, race or SES.

During this century of 'g' model supremacy there have been other theoretical positions. During the 1930's Thurstone, (1938) partitioned and developed tests for several intelligences or Primary Mental Abilities, and Guilford (1967, 1988) developed a comprehensive triaxial partitioning model. Both of these approaches have considerable scientific promise but remain primarily specialty concepts while the 'g' model remains the tool of choice. More recently Sternberg (1985, 1989) developed a triarchic model of intelligence and Gardner (1983) posits seven different independent types of intelligence but neither of these have been fostered by the test publication establishment or developed beyond the initial stages.

The contributions of Wechsler to thinking about intelligence and the continued growth of interest in intelligence testing, are largely due to Wechsler clarification of the Binet Simon approach. It is Wechsler who began the process of scientific analysis of the complex event we call intelligence, so necessary to progress in science. Without this clarification intelligence might have remained a much greater mystery, than it presently is. The rampant misuses of the Wechsler instrument, of which we are all guilty, are not the fault of Wechsler, who gave us an extremely useful and easy to administer, tool.

**Some concerns about the use of the data compression measurement model**

Aside from reliability and interpretation problems there are several effects arising from the use of data compression for the assessment of individuals for treatment purposes. One major flaw is that as one compresses data you also move the result up to a higher level of abstraction. Thus a child's standard score on a reading test is not really about the child at all, but about his place in his class or in the standardization sample. Such information is neither educational nor psychological, as we have always presumed, but is sociological group data. Similarly, the mean score for a classroom of children is not about the children, or the class, but about the relation of the class within the school. Thus, the more data one compresses into a single score the less it relates to an individual data point. Those data compression measures which cause the most stir in the news, and are bandied about by politicians: Intelligence tests, Reading, Writing and Arithmetic tests, are not psychological measures, but sociological measures which tell us more about group behavior than about the child.

The psychologist, the teacher, and particularly the neuropsychologist and the rehabilitation therapist, are interested in what goes on within the child. Data compression not only hides the individual differences, but allows the reporter to throw away an individual persons data (outliers) when it does not neatly fit into out preconceived notions of "goodness"

Second, compressed data acts to create categorical "diagnoses" which are unrelated to specific individuals or to treatments. Even our touted normed individual psychological tests mostly provide data about where the individual fits in some comparative norm group, and very little information about the individual or how he achieved that score.

Third, The "mass action" 'g' model totally begs the question of how the brain works. Verbal IQ tests measure products. They deal primarily with school related acquired content, "what" has been learned, and not process. "how" the individual learns. In turn, this emphasis on content or product assessment leads to content tutoring of information rather than treatment of processing deficits. Content product information is more susceptible to racial and cultural bias distorting the results for all individuals who deviate from the mean.

It is clear, if we are to understand how an individual mind works we need a new kind of assessment designed to probe specific individual differences so that we may respond to, treat, or compensate for, a specific learner's individual differences; rather than lumping vaguely similar children in gross categories for warehousing or assembly line instruction

**How do we solve Dr Buros' conundrum?**

As Dr. Buros indicated, the best of our data compression tests fail to provide data sufficient to allow us to clearly differentiate two individuals. These data compression assessment tools have tended to focus on *what* it is a person knows. A history test or the WISC Information or Vocabulary. Other tests assess whether an individual can perform a complex process like reading comprehension or block design. These tests do not show *how* a person acquires knowledge. What processes he performs to accomplish reading comprehension remains a mystery.

While the 'g' model attempts to compress information into a single global number for ease of communication. Focused Process Assessment (FPA) seeks to fractionate information into smaller and reliable process oriented parcels. What is lost in ease of communication is gained in accuracy of diagnosis. FPA is also different from the customary product assessment (Druikers, 1978) in that, rather than questioning *what or how much* one knows, FPA explores *how;* the processes whereby human cognition takes place, (Kingsley and Gary, 1973, Cohen & Squire, 1980; Gagne 1982) and the neural pathways activated by various processes (Kaplan, 1988). FPA explores human learning and cognition by examining detailed cognitive processes and there by assessing the efficiency of the underlying neural circuits activated by verbal learning.

> *"Science may be described as the art of systematic over-simplification." (Karl Popper, August 1982)*

**Levels of cognition:**

First, before describing Focused Process Assessment in detail, let us talk about the organization of knowledge as nested concepts. Knowledge about an event can be organized into an hierarchical sequence of concepts each finer and more detailed than the previous, just as Newtonian physics relates to the motion of quarks. Each of the finer levels is a part of the next higher level, and contains, or is the amalgam of the information in still finer conceptual levels. This should come as no surprise for this nested concepts model is used in the Wechsler tests verbal subtests are nested in VIQ which in turn is nested in FSIQ.

**Rule 1:**

The higher on the conceptual hierarchy level, the more global the score, that is the more sub concepts and more information is compressed into the single score, conversely the less specificity in the information.

**Rule 2:**

The higher the hierarchical conceptual level the less the contribution of any bit of information and the more likely significant information will be hidden.

**Rule 3:**

Inference is always unidirectional toward the more encompassing concept, thus one can infer from a reading standard score something of the relationship of the child to school work, but nothing about how the child arrived at that score. By the same token one can infer something about how the child reads from his score on a phonics or a vocabulary test. But if one wishes to find out why the phonics test score is low one must delve into its component knowledges and processes. This the inference chain is stronger in the direction of the larger score.

**Rule 4:**

One enters a conceptual hierarchy at different levels for different purposes. An economist studying the gross national product has little interest in my personal income although theoretically it is a part of his data. I, on the other, hand have a deep concern with my income and a rather tangential regard for the GNP. Thus the legislator wants one level of information from the schools, the school administrator another, while the teacher needs reliable information at still a finer level. and the psychologist at a still finer level.

A major problem for school psychologists is the mandate to provide higher order test results, useful to the administration and the state department of education, but of little value to teachers and remedial specialists. Further the regulations prevent psychologists from probing deeper than is mandated by the administration. School psychological assessment has, over time, become pro forma and falls far short of realizing its potential to assist teachers and children. Many school psychologists have devolved into middle level administrators, with most of their professional time spent holding meetings and moving special education paper.

## Measurement Analogues for Human systems

| Order of Magnitude | Level in Nervous System | Level of Measurement | Example of Measurement |
|---|---|---|---|
| 1 m | CNS | 'g' | FSIQ |
| 10 cm | Systems | Composites | VIQ |
| 1 cm | Maps | Factors | Memory |
| 1 mm | Network | Tasks | Serial Learning |
| 100 $\mu$m | Neurons | Processes | Seriation |
| 1 $\mu$m | Synapse | Specific Responses | A neural connection |
| 1 A | Molecule | Neuro-transmitter | ACTH GABA, etc. |

Figure 2.1 indicates the levels of understanding of the nervous system related to the measurement level employed (modified from Churchland, 1988)

These levels of understanding the nervous system are imposed by the type of reliable measurement employed. Thus a 'g' model test provides usable information about the global functioning of the total CNS but very little specific diagnostic information.

The deeper levels of understanding neural functioning require reliable focused tools designed specifically to probe at that level. Reliable Focused Process Assessment tools are required to amalgamate the findings of psychology with neuroscience

In essence one can enter this hierarchy of information at any level that is of interest only after it has been explored. The business of Science is to progress from the more complex global concepts to finer and finer more accurate level. This is, in the big picture, an orderly, but often tumultuous progression as each step in the advance is promulgated.

Given our limitations we are forced to view the world as hierarchies of knowledge. Exploring the same subject, the perceived truths of each investigator may vary, even contradict, those perceived by equal competence at another level of investigation. Truth then, is dependent upon where in this hierarchy one chooses, or is able to explore as well as what one explores.

How a reductionistic assessment model might play out in an academic setting

| | |
|---|---|
| Level I | IQ test 'g' model maximum data compression basically a sociological tool. Presumably Measures all intellectual activity. The information is of little value to the neuropsychological practitioner, the rehabilitation therapist, or the teacher, and important and useful for administrators, politicians, lawyers etc. |
| Level II | Reading comprehension test partitions intellectual activity into a major global "academic" component of little use to the neuropsychological practitioner or the rehabilitation therapist, of moderate value to teachers, and important and useful for administrators, politicians, lawyers etc |
| Level III | Standardized Phonics test Partitions reading into major components, of some use to the neuropsychological practitioner, or rehabilitation therapist, is valuable for teachers, and of little value to administrators, politicians or lawyers . |
| Level IV | Specific Letter identification, letter-sound correspondences or CV blending underlying phonics skills partitions phonics into tasks useful for neuropsychological practitioners, rehabilitation therapists and teachers and, of little or no value to administrators, politicians or lawyers. |
| Level V | Short term memory, response speed, serial learning are some basic learning processing skills underlying knowledge acquisition, useful to the neuropsychological practitioner, the rehabilitation therapist and to the teacher (perhaps with special training) of little or no value to the administrator, politician or lawyer. |
| Level VI | Rehearsal, impulsivity, seriation, cross-modal efficiency are some basic neurocognitive processes underlying Short Term Memory and serial learning. This level of analysis is very useful for neuropsychological practitioners, rehabilitation specialists and teachers( probably with some training) and of no value to the administrator, politician or lawyer. |

Now that we have described the levels of access to information let us apply this. as is obvious levels IV, V, and VI are most important to neuropsychologists, therapists and teachers, and also provide the most differentiating information about individual students and how they process and accumulate information

The following features distinguish Focused Process Assessment (FPA) from more traditional 'g' model assessments.

**Declarative vs. Process Information**

Perhaps the most significant difference between "g' model assessment and FPA is the distinction between declarative knowledge and cognitive processing. Most achievement tests and verbal intelligence tests assess "what" an individual knows, and by compiling the answers to a series of factual questions the instruments are able to establish "how much" content or declarative knowledge the individual has acquired. From this information we may attempt to make inferences about the rate of acquisition of content, (always assuming a consistency in race, culture and environment and education). Composite 'g' model testing primarily measures declarative and episodic information.(Cohen & Squire, 1982; Tulving 1983) The basic assessment question is - "WHAT" do you know?' and with the exception of Arithmetic subtest, verbal intelligence is a measure of " HOW MUCH" content information the individual has accumulated in a stipulated amount of time. There is little evidence for "HOW" one acquired the information. From the clinician's point of view, declarative testing provides little information about what may have been the cause of a deficit or what treatment might be developed to correct it.

In contrast, The major question for FPA is "HOW" you know. FPA uses primarily very simple well known stimuli to assess the efficiency of the processes by which an learning act is performed. What the learner does to acquire information and solve problems. With no content load and the focus upon "HOW" information is processed, FPA instruments largely abrogate racial, cultural and environmental effects.

**Analysis:**

Focused Process Assessment moves in the opposite direction from 'g' model assessment. Intelligence tests tend to use a synthetic model and combine a number of subscale scores into single score to represent global or overall ability. FPA attempts to analyze complex processes into the sub-processes necessary to perform the complex act and to reliably measure the efficiency of these specific sub processes which contribute to complex forms of learning. FPA model assessment does not produce global overall scores. The goal of FPA is diagnosis of specific individual neurocognitive processing differences which contribute to learning efficiency

**Reliability:**

FPA model instruments are designed so the unit of interpretation is the single subscale score. This score must be accurate. High subtest reliability is critical. In FPA subtest reliabilities, should meet or approach the recommended .90 necessary for stable interpretation of individual differences (Anastasi, 1983; Guilford, 1953: Nunnally, 1970; Ysseldyke et al, 1980). In one FPA tool the BLT-NE (Bloomer, 1978, 1980, 1999) 85% of the reliabilities are .85 and above. In contrast, with the WISC-III only 17% of the subscale reliabilities reach the .85 level. Note that in 'g' model instruments, where subtest reliabilities are not essential reliability is often sacrificed for ease and speed of administration. Hence, the metric certitude implied by using an empirical test instrument, is not truly available in subtest interpretation.

**Sensitivity:**

While global Scores hide specific individual information, the high reliability of subtests in the FPA model assessment allows the clinician to pinpoint wider range of aberrant processes and inefficient neural circuits. It shows the clinician specifically where treatment effort or further exploration must be focused and is sensitive to change in specific skills or processes. The composite 'g' score is not particularly sensitive to fluctuations in specific abilities, since large changes in one subtest can be easily masked by the weight of a multitude of other variables. Scientific reductionism increases the number of avaliable relevant variables for treatment.

**Developmental sequencing:**

The FPA model was designed to follow the developmental sequence of neural plasticity from the brainstem to cortex (Kandel, Schwartz, & Jessell, 1994). To allow for testing the influence of prior process development, each successive task is contingent upon the skill and efficiency acquired by the preceding tasks. This allows the clinician to pinpoint processing problems in a developmental contingent relationship and to design treatment plans related to these contingencies.

'g' model assessment while it assigns an order to items related to their difficulty by age of the individual, neither the subtests, nor the items themselves need to bear a theoretical relationship other than to age sequenced item difficulty and general type. Thus failure of one item tells us little or nothing about why the next item is passed or failed.

**Subtest Interpretability**

FPA tasks are simple and uncomplicated which reduces the interpretation options, making interpretation more accurate. The FPA tasks of the BLT-NE are also developmentally sequenced in a way that allows the clinician to rule out problems with less complex and more primitive neural circuits. Assessing specific aspects of learning processes narrows the range of interpretation such that each task has limited interpretative variability. In turn this leads to treatment specificity. Simple assessment tasks prevent confusion.

On the other hand, 'g' model subtests, in addition to low reliability and the high probability of unstable scores, when viewed from a processing perspective, are extremely complex, allowing numerous interpretations -- Is a low score on the Wechsler Picture Arrangement the result of poor, visual perception, or sequencing, or pictorial interpretation, or verbal comprehension, or motor ability, or a combination of these or other processes? These broad and complex subtests represent an advantage in 'g' model testing since the broad spectrum of cognitive processes are more likely to have elements of 'g'. On the other hand, back to Dr Buros conundrum, individuals with different subscale strengths may achieve the same 'g' for very different reasons. Most "how to" books on intelligence test interpretation provide a variety of possible interpretations for each subtest.( Kaufman, 1994; Sattler 1993)

**Diagnosis vs. Categorization**

Composite indices from 'g' model assessments are commonly employed to provide "cutoffs" or are used in discrepancy models to assign a "diagnostic category" to an individual. All LD's or ADD's or MR's are clearly not the same. Further, these individual differences directly effective treatment. Using these generalized "diagnostic" categories it is only possible to prescribe broad treatments such as "Structured Learning Environment" or "Stimulant Medication" broadside group treatment for everyone in the category.

The FPA model does not allow direct categorical "diagnosis" in the traditional sense. Diagnostic statements derived from FPA are more likely to state that this learner has an inefficient rehearsal processes, or this learner tends to over-sequence material while learning or the brainstem is not highly responsive to verbal materials. This type of diagnostic information does not lend itself directly to such categorizations as Learning

Disabilities or Attention Deficit Disorder, but it allows the clinician to hypothesize directly "why" this individual falls in such a category and provides specific information for designing treatment plans.

**Relationship to treatment.**

Process tasks are generally simple enough that direct interventions are simple to construct, and, like practicing an habit, as the neural circuits become more facile, they are easy to measure using reliable FPA's time, frequency or estimates of smoothness. Many of these sub patterns or procedural knowledges generalize easily or can be generalized by specific transfer therapy and in turn may effect a wide range of behaviors. This is not to suggest that the treatments are necessarily effortless. Changing a neural structure which has passed its period of plasticity is a long, arduous task requiring massive patience on the part of the therapist and intense motivation from the patient.

Now let us compare FPA with the data compression 'g' model, somewhat more specifically Figure 2 below shows a point by point contrast between the two measurement models.

## CONTRASTING FPA WITH 'g' ASSESSMENT MODELS

| **Focused Process Model** | **Data Compression 'g' Model** |
|---|---|
| 1. Analysis | 1. Synthesis |
| 2. Multiple meaningful scores | 2. Unitary global scores |
| 3. No composite scores | 3. Few composites |
| 4. Multiple scores, Complex Interpretation | 4. Single score, Simpler interpretation |
| 5. Highly reliable subtests | 5. Reliable composite scores |
| 6. Simple tasks | 6. Complex Subtests |
| 7. Single subtest meaning | 7. Multiple subtest meanings |
| 8. Tasks related neuro- developmentally | 8. Subtests internally age related. |
| 9. Neurologically sequenced | |
| 10. Procedural knowledge | 9. Opportunistic neuro- relationships |
| 11. Content free | 10. Declarative knowledge |
| 12. Culture fair | 11. Content dependent |
| 13. Specific neural circuits | 12. Cultural bias |
| 14. Specific diagnoses | 13. Overall cognitive function |
| 15. Individualized score patterns | 14. Categorical "Diagnosis" |
| 16. Direct treatment plan related | 15. Cutoff and Formulae |
| | 16. Generalized group treatment plans |

The Bloomer Learning Test - Neurologically Enhanced as a Focused Process Assessment tool is designed on a neurodevelopmental learning model. Below are a description of the level V variables which we will use in the remainder of this paper.Figure Level V neurocognitive processing measures from the BLT-NE

**Domain 1 Response Speed:**

Response Speed The rate repetitive copying of a single letter is related to midbrain activation, forms a comparative basis for Level VI variables of automaticity, persistence and arousal need.

**Domain 2 Short Term Memory**

Short-Term Memory (STM) - The number of letters or words a child can recall from a single presentation, STM is generally considered to activate the left temporal lobe and motor areas differentially according to medium. We will use three measures of written response short term memory

Visual Sequential Short Term Memory (VSTM)
Auditory Short-Term Memory (ASTM)
Visual Simultaneous Apprehension Span (VAPP)

These variables allow us to explore the Level VI variables of Impulsivity, Rehearsal, Sequencing, and Working Memory. Combined with the auditory and visual verbal response memory tasks we can explore Cross Modal efficiency and stimulus and response mode efficiency.

**Domain 3 Verbal Learning**

Serial Learning (SERIAL) - The acquisition of correct responses on a four trial serial presentation-free recall list learning task. Serial Learning is thought to involve the hippocampus and the parahippocampal region. Serial Learning forms the basis for Level VI variables of Learning Set, Acquisition, and Seriation.

Free Association (ASSOC) - the number of associative responses to single word stimuli written in one minute. Association is thought to activate the associative areas in the frontal lobes. The Association task allows us to develop level VI variables assessing spelling, vocabulary and Cortical Arousal

Paired Associate Learning (PA LEARN) - Fact learning, the ability to learn systematic connections between stimuli. Activates the parahippocampal regions and posterior associative regions

**Domain 4 Concept Formation**

Concept Recognition (CRECOG) - The ability to recognize similar characteristics or attributes of concepts.

Concept Production (CPROD) - The ability to identify a concept from exemplars.

## How does FPA work in Practice

It is always nice to develop abstract structures of how the world ought to function but sometimes the impingement of reality is disappointing. We have been developing this model for nearly 35 years and the findings to support our expectations. The next section of this paper will present several pieces of empirical evidence in relation to the follow topics.

1. How does FPA relate to individuals with learning disability?
2. Is FPA Neurocognitive process assessment related to traditional intelligence measures?
3. Is FPA related to academic achievement?
4. Does FPA predict future Academic Achievement?
5. Small group FPA treatment of a specific serial learning disorder:
6. Can FPA be applied to curriculum design? with what results?
7. How does FPA relate to some neurological functions?
    a. facial recognition
    b. Extra pyramidal nervous system
    c. Frontal lobes

**1. Neurocognitive processing and Learning Disabilities**

Customarily a person with a learning disability is defined, or "diagnosed" by a significant discrepancy between Intelligence and Academic performance. The federal guidelines upon which this formula is based define an LD in terms of a Central Nervous System Dysfunction which is at the basis of the poor academic performance. It is the custom to assume a CNS dysfunction exists if the appropriate discrepancy is found, rarely is the child probed further for closer CNS information

Recently there have been a number of concerns expressed in the literature about the usefulness of intelligence tests and in fact all 'g' model tests for diagnostic purposes Folstein, (1989) Lezak (1988, 1995). Rescheley 1980. Suggesting than such compounded scores hide any true diagnosis. On the other hand Lezak (1995), Cohen and Squires, (1980) and in particular Kaplan, (1988) have been arguing that "process assessment" which explores "how" new knowledge is acquired rather than "what" has been acquired, as being much more relevant, particularly in the treatment of individuals following cerebral insult. This argument is not only valid for Closed Head Injury, but also for school learning related problems

**What does FPA show about learning disabilities**

Our sample included one hundred and forty-three (143) previously categorized students with a learning disability, (109 males, and 34 females) in grades 2-11. These youngsters were referred to the Diagnostic and Prescriptive Service Unit clinic at the University of Connecticut for further diagnosis, (Bloomer, & Norlander, 1990).

Table 1. Bloomer Learning Test (BLT-NE): (Level V analysis)
Means, Standard Deviations and percent falling one or more SD below the mean for Learning Disabled group (N = 143) (Mean = 10, SD = 3)

| BLT TASK | MEAN SCALED SCORES | STANDARD DEVIATION | PERCENT LESS THAN SS=7 | DEVIATION FACTOR |
|---|---|---|---|---|
| DOMAIN 1 Response Speed | | | | |
| ACTIVITY | 9.00 | 3.00 | 30% | 1.88 |
| DOMAIN 2 Short Term Memory | | | | |
| VIS-SEQ | 8.49 | 2.30 | 28% | 1.75 |
| AUDITORY | 9.02 | 2.43 | 24% | 1.50 |
| VIS-SIMUL | 8.50 | 2.77 | 32% | 2.00 |
| DOMAIN 3 Learning Processes | | | | |
| SERIAL | 7.92 | 2.62 | 47% | 2.94 |
| ASSOC | 8.90 | 3.47 | 36% | 2.25 |
| P-A LEARN | 7.13 | 3.09 | 47% | 2.94 |
| DOMAIN 4 Concept Formation | | | | |
| RECOGN | 11.11 | 2.76 | 9% | .56 |
| PRODUCTN | 9.42 | 2.97 | 23% | 1.44 |

The mean age of the sample was 12.3 years and the mean grade 5.3. The mean IQ of the sample was in the normal range. The mean WISC-III Verbal IQ for the sample was 96.5 and the mean Performance IQ was 99.3. Data were collected from a variety of school systems, primarily in eastern Connecticut. The Connecticut State Department of Education guidelines define learning disabilities as a significant discrepancy between "ability" (read, IQ) and Academic achievement. Significant discrepancy is usually defined as a difference of 1.5 SD.

The BLT-NE (Bloomer 1980) was administered individually to each of these pupils by pre-doctoral school psychology interns. The individual results were combined into the table for illustrative purposes.

Please note this is an accumulation of individual data and not a"profile" of an LD group or necessarily any specific LD. An Individual with a Learning Disability label may be deficient on one or several of these measures. Use of FPA will allow reliable description of the individual strengths and weaknesses and lead directly to treatment possibilities not possible under data compression models. The following are the groups' cumulative results.

1. 47 percent of the LD's achieved a scaled score of 7 or less on the SERIAL LEARNING and on the PAIRED ASSOCIATE Tasks of the BLT-NE. This discrepancy is nearly 3 times normal expectation. These tasks involve neurocognitive processes and are thought to systematically access the hippocampal system and related cortex. We have had some success training these processing skills,

2. LD's do not differ significantly from the normal population on the AUDITORY SHORT TERM MEMORY Task. This is not surprising since the WISC-III used to identify them is primarily an auditory test. This task involves the superior temporal lobes. Differences are found from "normals" for nearly twice as many LD's in VISUAL SHORT TERM MEMORY, VISUAL APPREHENSION SPAN, tasks both thought to involve the inferior temporal lobe.

3. LD's differ significantly from the normal population on CONCEPT RECOGNITION and CONCEPT PRODUCTION. It is clear that an LD has some strengths Concept Recognition, which assesses the ability to move up the abstraction hierarchy of knowledge, appears to be one of these strengths for many LD's. These tasks are primarily related to the prefrontal cortex. It is skill on these conceptual that often differentiates LD's from Slow Learners.

4. Approximately twice as many LD's perform one standard deviation or lower than expectation, on ACTIVITY, a speeded variable, assessing efficiency in the midbrain; and FREE ASSOCIATION the acceptability of conceptually realted information, primarily a function of the association cortex.

I need to reiterate that deficiency in any one or several of these processing variables may contribute to a learning disability and each individual case has its unique profile and similar profiles between two LD's does not necessarily mean identity, since analysis at a Level VI or finer may show wide differences. The advantage of analysis at this level is that techniques for treatment of the processes do exist and have been applied with some success.

2. **Is FPA Just another IQ test?**

Since we have been arguing that FPA and Intelligence or 'g' model tests are different these same data provide us the opportunity to explore that position

The literature as far back as Garrett (1928) and Garrison (1928) and Woodrow, (1940) has suggested a low relationship between learning ( information Processing) and Intelligence. Discussions of this issue by Sternberg (1985) Brown and French (1979), Swanson (1987a), and others from a variety of perspectives clearly point out that intelligence is not a unitary phenomenon but may involve a number of cognitive processes each of which may relate to intelligence differentially. Consequently current literature in the area of learning disabilities calls for an examination of the way in which children process information in various learning situations. (Barkley & Hagen, 1982)Brown 1978, Kooligan and Sternberg (1987) Swanson 1982, 1987a, 1987b).

Since there was WISC data on each of the youngsters on the preceding sample we were able to perform a factor analysis with a varimax rotation which produced the following five factors.(Bloomer & Kulikovich, 1997)

Table 3 presents the Varimax rotated factor matrix for the BLT and WISC-III subtest scores (factor loadings less than .35 have been omitted)
BLT and WISC-III Scale Scores for Learning Disabled Children: Varimax factor matrix (=143)

| VARIABLE | FACTOR 1 | FACTOR 2 | FACTOR 3 | FACTOR 4 | FACTOR 5 |
|---|---|---|---|---|---|
| VIS-APP | LEARNING | VERBAL | PERCPT | CONCEPT | SPEED |
| SERIAL | .79 | | | | |
| ASSOC | .75 | | | | |
| P-A LRN | .72 | | | | |
| AUD-STM | .70 | | | | |
| VIS-STM | .68 | | | | |
| | .64 | | | | |
| VO | | | | | |
| CO | | .78 | | | |
| IN | | .73 | | | |
| SI | | .72 | | | |
| PA | | .71 | | | |
| AR | | .48 | .47 | | |
| | | .45 | | .37 | |
| BD | | | | | |
| PC | | | .82 | | |
| OA | | | .73 | | |
| | | | .72 | | |
| CNCP REC | | | | | |
| CNCP PRO | | | | .85 | |
| | | | | .82 | |
| CD | | | | | |
| ACTIVITY | | | | | .82 |
| | | | | | .80 |

The following five factors were extracted.

1. Learning Factor
The first factor measures verbal learning and includes tasks measuring Short Term Memory, Serial Learning, Free Association and Paired Associate Learning and follows a classical learning model. This factor accounts for 27.8 Percent of the variance in the matrix.

2. Verbal Intelligence
The second factor primarily measures storage and retrieval of declarative information, and includes all of the verbal intelligence subtests on the WISC-III and in addition Picture Arrangement loads on this factor as well as on factor 3 Verbal Intelligence accounts for 13.0 percent of the variance.

3. Perceptual Organization.
The third factor includes all the WISC-III subtests which comprise the perceptual organization factor of the WISC-III scoring. This factor accounts for 8.0 percent of the matrix variance.

4. Concept Formation
The fourth factor assesses the ability of the learner to form concepts from exemplars and to move in conceptual heirarchies is comprised of the Concept Recognition and Concept Production tasks of the BLT. This factor accounts for 6.8 percent of the variance.

5. Response Speed.
Factor 5 is the only factor where a significant amount of the variance was contributed by each of the tests. The Activity task of the BLT and the coding subtest of the WISC-III both measure response speed and jointly contribute 6.5 percent of the variance to the matrix.

Overall the factor matrix accounted for 63 percent of the total variance, the BLT Learning tasks accounted for 34.6 percent and the WISC-III for 21.9 percent. 6.5 percent was contributed by the cross test Response Speed factor. This lack of overlap in the factor structure makes it clear that Learning tests measure processing skills that are very different from those explored on intelligence tests. We are in fact probing areas which are not assessed with intelligence testing and offer support to the original Garret (1928) and Garrison (1928) positions.

**3. Does FPA relate to academic behavior**

In one instance we administered the BLT (Bloomer, 1980) to a total school, five hundred and eighty-one children, grades one through six, from a mill town adjacent to a small city in eastern Connecticut and correlated the results with the achievement and cognitive abilities results from the Comprehensive Test of Basic Skills.

Table Correlations of BLT Level V variables with academic achievement and Cognitive abilities measured by the CTBS, (N=581_)

| **Variable** | COGNITIVE ABILITY | READING | VOCABULARY | SPELLING | MATHEMATICS COMPOSITE |
|---|---|---|---|---|---|
| ACTIVITY | -.16 | .37 | .65 | .40 | .49 |
| VSTM | .40 | .25 | .65 | .44 | .53 |
| ASTM | .47 | .24 | -.03 | .26 | .52 |
| VAPP | .49 | .17 | .21 | .07 | .54 |
| SERAL | .26 | .22 | .16 | .49 | .41 |
| ASSOC | .32 | .64 | .46 | .41 | .66 |
| PALRN | .39 | .30 | .55 | .40 | .42 |
| CNCPT REC | .40 | .62 | .41 | .52 | .38 |
| CNCPT PROD | .30 | .69 | .42 | .56 | .52 |
| COGNITIVE | 1.00 | .33 | .41 | .51 | .62 |
| COGN $R^2$ | | .11 | .17 | .26 | .38 |
| MULT-R | .80 | .85 | .82 | .87 | .77 |
| $R^2$ | .64 | .72 | .67 | .76 | .59 |
| ADJ. $R^2$ | .51 | .61 | .58 | .72 | .55 |

r=.08; p=.05,

$r=.11$; $p=.01$,

Several things are evident from this table.

1. The CTBS Cognitive Abilities measure predicts less of the academic achievement variance for Reading, Vocabulary, and Spelling than the Level V BLT variables.

2. Several of the BLT Level V variables producd substantially higher univariate correlations with academic variables than the Cognitive Ability measure.

3. The patterns of the BLT Level V simple correlations differ with each criterion variable suggesting that differential skills are called upon to perform differing tasks. With further study, specific processing patterns at a group level might be developed for comparison with individual patterns.

4. The respectable correlation of Level V variables with mathematics achievement produces a respectable multiple correlation, suggests processing is unrelated to content. One may employ a the same or similar processes for differing materials.

**4. Does FPA predict future achievement**

The data for this study were drawn from two fourth grade classrooms in a middle SES suburb adjacent to a middle sized city in Massachusetts. the population consisted of 32 girls and 35 boys ranging in age from 9 yrs 8 months to 11 yrs 6 months. The students were administered the Iowa Test of Basic Skills in both fourth and fifth grades. They were also given a truncated version of the level V variables from the BLT-NE and they were also administered the Lorge-Thorndike Intelligence test. during the fourth grade. Testing was administered during April of the school year. These data were collected by Dr. James Shea of Springfield College in Springfield MA (Shea, 197).

Table presents the simple correlations for year 1 and year 2 as well as the multiple correlations of the BLT Level V variables with achievement and simple gain from grade 4 to grade 5. The intelligence scores account for between 41 percent and 49 percent of the variance on reading, vocabulary and spelling in the first year and this is increased in the 2nd year to between 45 percent and 61 percent of the variance in the second year for the same variables.

FPA Level V variables accounted for between 59 percent and 64 percent of the variance, about 15 percent more than intelligence measures in the first year. and between 66 and 77 percent of the variance, or 20 percent more than intelligence in the second year for the same achievement variables. Similar discrepancies between the amount of variance accounted for occur in the language usage scores and the overall language scores. In our sample both intelligence and FPA level V variables accounted for similar amounts of the variance 55 and 53 percent respectively. A disparity in accounted for variance of 17 percent in favor of FPA, was again found with math problem likely because of the increased reliance of language.

There was also a wide discrepancy in the prediction of the change in reading scores between year 1 and year 2 intelligence test scores predicted only 8 percent of the change while the FPA variables were able to predict 38 percent of the variance, an increment of 30%

Table Predictive Validity: Simple and multiple correlations of achievement variables with level V processing variables and Intelligence for the same pupils in fourth and fifth grades.

| VAR | Read1st | Vocab 1st | Spell 1st | Read 2nd | Vocab 2nd | Spell 2nd | Usage 2nd | Lang2nd | Math Comp | Math Prob | Read GAIN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTI | -.06 | -.05 | -.03 | -.21 | -.14 | .08 | -.13 | -.05 | -.15 | -.23 | |
| VAPP | .52 | .42 | .62 | .52 | .49 | .64 | .59 | .69 | .54 | .49 | |
| SERL | .38 | .36 | .38 | .38 | .30 | .47 | .36 | .47 | .17 | .19 | |
| ASSO | .48 | .36 | .48 | .44 | .39 | .51 | .40 | .44 | .16 | .02 | |
| PALN | .40 | .51 | .40 | .58 | .46 | .42 | .47 | .52 | .46 | .41 | |
| CREC | .44 | .47 | .44 | .47 | .39 | .40 | .61 | .52 | .37 | .44 | |
| CPRO | .51 | .51 | .51 | .65 | .54 | .54 | .56 | .59 | .51 | .53 | |
| IQ | .70 | .64 | .67 | .75 | .67 | .68 | .56 | .74 | .74 | .59 | .28 |
| IQ $r^2$ | .49 | .41 | .45 | .56 | .45 | .46 | .31 | .55 | .55 | .35 | .08 |
| R | .80 | .77 | .79 | .87 | .81 | .86 | .87 | .88 | .73 | .72 | .62 |
| $R^2$ | .64 | .59 | .62 | .76 | .66 | .74 | .76 | .77 | .53 | .52 | .38 |

It should be noted that the purpose of this type of study is to establish that FPA variables relate to academic achievement. From these data one may draw inferences about the general nature of the processes involved in academic achievement in groups. These present data do not allow application to an individual reader, nor should the individual be compared with these group data when attempting to diagnose reading difficulties. It is the individual profile that affords information for decisions about an individual.

**5. Small group treatment of a specific serial learning disorder:**

Three students in 7th or 8th grade were referred for academic difficulties. A Level V assessment found all three were found to be deficient in BLT Level V Serial Learning. Serial Learning measures the ability to isolate a group of unrelated but known stimuli into a group and to maintain and increase the number of relevant items over several trialsand to maintain a sequence of the responses. Serial skills enter into a wide variety of school learning activities. Usually serial learning as a process is mastered by fifth grade. It was decided use a process intervention to teach the serial learning process (Bloomer, 1985)

The students met as a group for a half hour twice a week for fourteen weeks. Since they were generally discouraged about their learning abilities, the first session was devoted to first proving to the youngsters that they could learn serial tasks. They compared their responses to an initial trial of auditory presentation/written response to a second repetitive trial to notice the gains. During this session various forms of remembering and learning were presented.

Thereafter, each session consisted of a four trial recall and relearning of the last list from the previous session and a four trial learning of 2 new lists. The lists were 12 four and five letter, common words. The first new list each session was an anticipation list where after the first trial on blank page they would attempt to write each stimulus before it was presented and then correct it after, the third list required writing the whole stimulus list after presentation for four trials. This was the list for recall on the subsequent session.

Post testing after 28 sessions indicated an significant increase in Serial Learning at the .01 level for each individual, and also an increase in Response Speed and Seriation also at the .01 level of confidence for each student. There was a significant improvement in BLT Level V Auditory Short Term Memory and significant transfer to visual written memory and learning. This treatment plan has been used successfully with other pupils and with other therapists, although on one occasion when attempted with a pupil in severe depression no change was found at post test (Milkowitz & Bloomer, 1985).

**6. The effects of Using FPA in curriculum design**

The standardization sample for the BLT has indicated a spurt in both Short Term Memory capacity and in Serial Learning abilities during the first three grades, tapering to a peak at fifth grade. This represents the Vygotskyian "zone of proximal development" and suggests that these features can be enhanced with careful nurturing. We, (Bloomer & Bernazza 1967) developed a beginning Reading/Typing program using a phonetic approach based on high discriminability sequence in a progressive part design. STM problems were minimized by presenting one letter at a time and its meaningful permutations through all the previously studied letters only. All work was done in conjunction with typing on a portable typewriter which automatically sequences all language. The pupils typed everything they read. Pupils were randomly assigned to treatment either reading typing R/T or traditional. There were two classes of each. The R/T program continued through first and second grades.

The major differences at the end of second grade were found in writing and spelling. Composition for the R/T pupils was assessed both typed and handwritten and compared with the traditional students. At the end of second grade the R/T pupils produced a mean of 158 words typed and 113 words handwritten. The compositions of the traditional students averaged 88 words. Sentence length and complex sentences were both significantly greater for R/T pupils in both handwritten and typed samples.

Mean reading level of the R/T/ pupils at the end of second grade was higher than the traditional pupils, but the differences were not significant. Spelling as measured by the Stanford achievement test was significantly higher at the end of grade 2.

Long term effects of R/T beginning curriculum: From third grade the experimental and control groups were mixed in regular classes and received traditional instruction. The first and second grade beginning R/T program continued for twelve years, and follow up was assessed by the Comprehensive Test of Basic Skills (CTBS) in grades three, five and seven. Mean IQ for the R/T program pupils was 102.3 and for the Traditional program 100.8 This difference was not significant.

A follow up study including all the pupils for whom there were CTBS records was conducted in 1980 (Bloomer, 1981) . In general the results showed an accelerated growth for the R/T program with increasing disparity from the traditional only group. The third grade CTBS scores indicated a grade equivalent of 4.2 for the traditional group and 5.1 for the R/T pupils. The difference of 0.9 grade equivalents was not significant. At the end of the fifth grade the traditional pupils averaged 5.4 grade equivalents and the R/T pupils were significantly superior at a grade equivalent of 6.5. By seventh grade the difference between the two groups was 2.0 full grade equivalents with the traditional group at 7.0 and the R/T group reading on average at the 9.0 grade level, significant beyond the.0001 level.

Transfer of the processing skills was indicated by a similar pattern of accelerated growth on each of the subtest scores of the CTBS including mathematics, study skills and language usage which were not related directly to the R/T program. The single exception to this was the Reference Skills subtest which showed much the same pattern but did not reach significance. Such widespread and continued effects are not the result of teaching content or declarative information, but result from early intervention in the children information process skills.

Effects of FPA on special education: In the spring of 1980 the sixth grade pupils were categorized by referral to any special education placement. There were 22 R/T past students in sixth grade and three or 13% were in some form or remedial or special education. Of the thirty traditional pupils thirteen of 43.3% were in remedial or special education a factor of 3.2.

We then surveyed the 238 pupils presently in grades three through six on their special education status. Of the 106 pupils who had been in R/T first and second grades, twelve, or 11.3% were in some form or remedial, special or tutorial education. of the remaining 132 traditional students forty three or 32.6 percent were receiving formal special help.

Since the pupils were originally randomly assigned to group and group mean measures of Intelligence were within one or two points and the students were mixed in grades three through six classrooms, we can posit that the differences in special education assignment were due to differences in treatment between R/T and traditional reading teaching. In this case the analytic principles of FPA were valuable in design of an effective beginning reading writing curriculum.

## V. How do Level V and Level VI measures relate to neurological functioning in face recognition, in the extrapyramidal system, the frontal lobes?

This research was conducted in the "Music and Minds" Program for individuals with Williams Syndrome (WS) at the University of Connecticut in June of 1999. Williams Syndrome is a rare autosomal genetic disorder usually with moderate mental retardation and numerous medical problems. Williams Syndrome are distinguished by their ability to carry on social conversations (Bellugi, Adolphs, Cassady, & Chiles, 1999). and to remember, and read emotions from faces. (Karmaloff-Smith et al., 1997)

Individuals with Williams syndrome present some unique opportunities to study the way the brain functions. Bellugi, Lichtenberger, Mills, Galaburda, & Korenberg, (1999) comment MRI studies have shown proportional sparing in WS of frontal, limbic and neocerebellar structures. Event-related potential studies have also indicated abnormal functional relationships of the neural systems for both language and face processing. Bellugi, et al., (1999) conclude, "The non-uniformity in the cognitive, neuromorphological and neurophysiological domains of WMS make it a compelling model for elucidating the relationships between cognition, the brain and, ultimately, the genes."

the music and minds program this presented a valuable opportunity to probe the relationship of our focused process assessment tools and some neurological probes. There were nineteen Williams young adults in the program differing numbers of them participated in different aspects of the testing so that the N of cases will be presented with each statistic. The WS were subjected to Standard frontal lobe

(Etlin & Kishka, 1999) and extrapyramidal function (Strub & Black, 1993) testing along with sections of the BLT-NE (Bloomer, 1999) As an add hoc study we used Pearson's correlation to probe for relationships. Since the N of cases was small and we were seeking and not confirming hypotheses we · used a somewhat more lax 10% level of confidence.

**Facial Recognition:**

Our first area of exploration is the relationship of facial recognition. WS were rated by the Music and Minds staff on a 3 point rating scale for facial recognition - good - average - poor. While group data has shown preserved facial recognition in WS (Karmilof-Smith, et al (1997) there were wide individual differences within out group. These ratings were correlated with BLT-NE Level V assessments of learning, memory, neurocognitive processing (Bloomer, 1999) and the functioning of the extrapyramidal neural system, Straub & Black, (1993) and frontal lobe function (Etlin & Kishka, 1999).

Considering the small N of cases, none of the variables produced a correlation significant at the.05 level but several correlations in the .40's and .50's did achieve the .10 level of confidence.

Facial recognition requires adequate function of several widespread areas of the brain. Prosopagnosia, or the inability to recognize faces is generally thought to involve damage to the mesial occipito-temporal junction (Damasio, 1985) Williams syndrome are reported to have normal facial recognition (Karmilof-Smith et al., 1997) Hence those with Williams syndrome are considered to be functional in that area of the brain at least in some of the WS.

However, Sergent (1994) indicates facial recognition is a more complex task, requiring a number of steps. First is encoding stimulation as a face a function of the calcarine fissure in the occipital lobe. The second is perceiving it as a face, generally considered a posterior medial function, in the area around the fusiform gyrus (Kanwisher, 1999). This is probably the area described by Damasio (1985).

Once we have determined that it is a face; age, race, gender, and emotional tone are determined. Sergent's (1994) P.E.T. scan studies indicate activation of the ventro-medial region of the right hemisphere when the task was to determine the sex of a face. Facial identity tasks, in addition to these areas, also activated the parahippocampal region of the right hemisphere and the orbito-frontal areas. This orbito-frontal activity may be reflected in the correlation between ratings of face recognition abilities and frontal lobe function (r.= -.47, p.=.10 N=10).

Our data suggest the possibility that facial recognition is related to both memory and learning. Visual Apprehension and Visual Short Term Memory correlate with facial recognition ratings (r.= .48, p=.06, n=12).; and (r.= .45, p.= .09, n=11) respectively. Further correlations with Serial Learning and with Seriation of (r.= .36 p.= .07, n=19); and (r.= .42 p.= .06, N=16), respectively suggest a relationship with learning.

We measured Impulsivity as the ratio of errors of commission related to correct responses on memory tasks. Impulsivity is apparently counterproductive to facial recognition. (r.= -.39, p.= .08, n=19). Whether one can infer from this negative relationship that sustained focus and concentration are necessary for facial recognition is an open question.

Facial recognition also appears to require an intact and functioning brain. The correlation with neurological probes of (r.= -.55, p.= .07, N=10) indicates a potential relationship between facial recognition and the functioning of the cerebellum, midbrain and the basal ganglia. In addition to the extrapyramidal motor system the facial recognition may also be related to functioning of the frontal lobes (r.= -.47, p.= .10, N=10)

These data suggest that facial recognition is a complex process related to a wide variety of cortical and subcortical functions. Using FPA analytic techniques we were able to uncover some potential underlying processes and increase our hypothesis base for exploring the anomalies that makeup

WS. The reader should bear in mind that none of these results reached the .05 level of confidence. Clearly more work needs to be done to sort this out. With a larger or more heterogeneous sample the results might have been quite different. Our results do suggest that using more analytic probes we may be able to clarify the relationship between facial recognition and neurocognitive processing in a manner not open to imaging studies

**FPA and extrapyramidal system:**

The extrapyramidal motor system involves the cerebellum, the pons and midbrain and the basal ganglia. The extrapyramidal system is responsible for balance, for the timing and coordination of eye movements, eye-hand coordination, and in fact all motor activities. The neurological exam (Strub & Black, 1993) involves a number of simple motor tasks which act as indicative of the functional efficiency of differing areas within the extrapyramidal system We performed this section of the neurological exam with the population of individuals with Williams syndrome. Our findings show about half of the WS population exhibit two or more extrapyramidal signs. We found functioning of the extrapyramidal system is related to a wide variety of BLT-NE Level V and Level VI learning, memory, and neurocognitive processes, at least within this Williams syndrome group. Our N of cases is small for most of these correlations and so several large correlations may not be statistically significant. Since we can do nothing with these data but speculate and generate hypotheses for future exploration, I shall include them in the discussion.

Perhaps the first thing to note is that extrapyramidal function does not relate strongly to any of the short term memory tasks. One might reason that STM is typically considered a temporal lobe function. Were not for the fact that the extrapyramidal function seems heavily related to learning and to some of the neurocognitive processes involved in the acquisition of material which are also commonly thought of as temporal lobe functions.

Serial learning, BLT-NE Level V. the ability to learn a list of words with multiple trials is a fairly complex process requiring the application of a variety of neurocognitive processes to the acquisition of verbal materials. Our data shows that serial learning is negatively related to positive extrapyramidal signs (r.= -.549, p.= .05 N=10) suggesting from our current hypothetical thinking that skill with serial learning may be dependent in part upon a functional cerebellum or midbrain.

Acquisition, BLT-NE Level VI. is an index of the learning or growth in the serial learning task with the short term memory component factored out. Like rehearsal it attempts to index the complex neurocognitive processing necessary for learning a sustained sequence of stimuli Our findings show Acquisition is related to the functioning of the extrapyramidal system. Our data show a moderate relationship between these two variables, r.= -.37 (p.= .17, N=10).

Seriation, BLT-NE Level VI. is a measure of the organization of the responses in serial learning. Seriation or sequencing responses in presentation order has been related to a timing function which controls when a specific response is to be made. This timing function is suspected to be a role of the relationship of the climbing fibers which bring information to the Purkinje cell fans which, in turn, have an inhibiting effect in the cerebellum. Given the fairly strong correlation (r.= -.60, p.= .06, N=8), with this limited sample, our data tend to support this notion, or some other concept of midbrain-cerebellar involvement the sequential organization and timing of responses.

Response speed, BLT-NE Level VI. assessed by the rate of simple, repetitive, non-cortical motor responses is a measure of the basic activation of the nervous system. It is presumed to be controlled by neurons in the midbrain, either the ascending reticular activating system as some purport, or by the dopaminergic pathways form the midbrain tegmentum. In either case our limited data support the notion of extrapyramidal involvement in the speed of response (r.= -.50, p.= .07, N=10).

Arousal need, BLT-NE Level VI. is a neurocognitive process measuring the change in rate of response with stimulus variation. Our data show it is related to the functional capacities of the extrapyramidal system. The poorer the extrapyramidal function the more likely stimulus variability will reduce the rate of response and the less tolerant of change in stimulation the individual becomes. The correlation between extrapyramidal function and arousal need is a moderate r.= -.36, (p.= .10, N=10).

Rehearsal, BLT-NE Level VI. is a neurocognitive process essential to learning. Our measure of rehearsal efficiency is derived from the relation between sequential STM presentation where the opportunity and or the requirement to maintain information is present , with simultaneous STM presentation where immediate recall eliminated the requirement for interim storage or processing.

Success with rehearsal appears strongly related to a functional extrapyramidal system, (r.= -.94, p.= .08). However we must be careful with these data since the number of cases on which our data is based is an N of only four (4).

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Thus we are able to relate basic neurological probes with our FPA assessments to explore some of the neural underpinnings basic Level V and Level VI variables. While these are not data we should take to the bank, it does appear that the relationship between extrapyramidal function and the neurocognitive processes which contribute to learning is worthy of further exploration. These findings extend those of Rae, et al (1998) who determined that deviant levels in cerebellar neurochemistry were correlated to performance on neuropsychological tests, including Verbal and Performance IQ, British Picture Vocabulary Scale, Ravens Progressive Matrices, and Inspection Time. Whether these findings are restricted to Williams, or whether they have wider application is an open question.

**Frontal Lobe:**

Frontal lobes are presumed to be activated when complex neurocognitive processes are activated. Working memory, decision making, attention, planning, inhibition and a variety of other executive functions are "Frontal Lobe functions", (Jernigan, Bellugi, Sowell, Doherty & Hesselink, 1993). the frontal lobes in WS are reported to be smaller than in a normal population (Grant, et al. 1996). Our series of frontal lobe probes derived from Etlin and Kishka, (1999) showed a wide variability in frontal lobe signs in our WS population. About half the WS in our sample demonstrated less than two frontal lobe signs. Evidence for the neurocognitive process disassociation of frontal lobe function from extrapyramidal function can be seen by comparison of the frontal lobe correlates with the extrapyramidal data.

First, we found many fewer correlates, between learning, memory or neurocognitive processes and frontal lobe function than for the extrapyramidal system, even by our present loose standards. The frontal lobe function was related to neither learning or memory in our sample. Does this mean the frontal lobes do nothing? No. it suggests that the simpler processes of acquisition and storage may be performed elsewhere, probably in the posterior brain, and activation of the frontal lobes is not called upon to perform these tasks. Essentially then memory was not found to have a high relation to either the extrapyramidal or frontal lobes.

We should say a word about working memory it is presumed by many to be a frontal lobe function . Since the advent of Baddeleys (1983) concept of "Working memory" the literature has been replete with studies, claiming to measure Working memory and to locate the working memory function within the frontal lobes. Many researchers use the Wechsler type Digit Span subtest, which is not very different in from the BLT-NE Short Term Memory tasks. Our evidence with this Williams Syndrome population does not support this claim. Working memory as measured by letter span and probably digit span does not relate to frontal lobe function, Of course, our N is small and our subjects are not normally distributed.

The real problem is: What is Working Memory? That which started out with Baddeley (1983) as a relatively general concept has been confused and made vague by a plethora of work in the literature attempting to work a wide range of tools, from problem solving, reading comprehension, and sentence repetition to digit span, into the working memory concept. Assuming the concept of working memory is viable, instead expanding it to the point of meaninglessness, science should be exploring just what it is that works during the working memory, and attempting to delimit the concept to a clear and useful notion.

Whatever the results of this debate, we did not find viable relationships between frontal lobe function and measures of Short Term Memory within the Williams sample.

There are however, two neurocognitive process measures which are related to frontal lobe function.

<u>Persistence:</u> is the ability to sustain the performance of repetitive task over time. In this instance the task is repetitive copying of a single capitol letter. Presumably this task requires little if any cortical arousal. Our findings show that the greater the number of frontal lobe signs the lower the persistence (r.= -.51, p.= .08, N=10). This is not surprising since impersistence or the inability to sustain attention is common in head injury effecting the frontal lobes and in particular the orbito-frontal region.

<u>Response Speed:</u> Of the two neurocognitive processes related to frontal lobe function, only response speed crosses between the two systems since it also relates to the extrapyramidal system function. Since response speed is a measure of basic activation, theoretically the neurons responsible for activation, be they dopaminergic or from the ARAS arise from the midbrain to pervade the whole brain. The correlation of response speed to frontal lobe signs is moderate and not significant, r.= -.37, (p.= .14, N=10)

**Summary:**

We have demonstrated the efficacy of a Focused Process Assessment in contrast to the data compression measurement model of the last century. The FPA model allows us to probe the human condition more deeply and accurately than we have been accustomed. FPA data will provide us with additional insights into the functioning or the nervous system and neurocognitive variables. Clinical application of the FPA model in the coming century will increase both our diagnostic and treatment capabilities.

**Is FPA the end of the analytic line?** No, thirty years ago we started using a classical learning model rather than a declarative knowledge model to explore school type verbal learning. This analysis eventually became level V and the level VI analyses evolved out of working with level V It is reasonable to assume that experience with level VI neurocognitive processes will point the way to still further levels of analysis.

**Is 'g' dead?** No! In the same sense that Newton's Physics was not abrogated by relativity theory, 'g' represents a hierarchical level or inquiry which still has uses in the popular, social, administrative, and legal areas, or where ever data compression and discussions require condensing. Just a Newtonian physics is limited in its scientific utility at a certain level of analysis so too are there limits to the data compression model

**What will diagnosis be like in the 21st century?** Process assessment will lead to an entirely different diagnostic system. As the categories become finer and more specific and discriminating. In lieu of a gross diagnosis of Learning Disability we shall be able to point out the neurocognitive processes which are less, or more, efficient which underlie the condition. A diagnosis of inadequate seriation skills might underlie an LD categorization. Under the old system the LD categorization would lead to the usual "structured environment" with "special help" (*read tutoring*) treatment plan, designed to help Johnnie or Suzy "Keep Up" with their class.

The old hoary categories will remain in place, the legal system, social agencies and school administrators are deeply bound to the nine categories of disability, recognized by most state departments of education and therefore fundable in schools, or the DSM categorical system bound into HMO's and insurance companies and the legal system. Gradually as a more analytic approach becomes recognized these process diagnoses and treatments will come to be included In DSM VII we may see diagnoses like Developmental Reading Disorder with Acquisition features (315.01) or Developmental Mathematics Disorder with Seriation features (315.14)

**What about treatments?** With FPA applied to the above example of a learning disability the neuropsychologist or rehabilitation therapist would focus on treatment on the seriation sequencing problem itself. Several therapeutic prescriptions for Level V and Level VI processes have been developed and tested. "Keeping up" is not a concern, and in many cases may be counter productive. "Keeping Up" is asking the child to perform tasks for which the basic processes are already known to be not functional. In effect the "keeping up" tutorial model with its impossible tasks generates anxiety and aversion. Classroom materials which are already tainted with failure are not used in process therapies. FPA treatments enable the child to perform the critical task in the absence of content loaded materials.

FPA treatment stimuli are simple, well known, and non-demanding. It is *how* these simple materials are processed that is the focus of the treatment. Process training takes place in numerous short sessions over a long period of time. These therapies usually are the province of the psychologist and the rehabilitation therapist simply because is difficult for school personnel to perceive of, and perform, treatments unrelated to the ongoing curriculum.

There are some therapies focused on specific tasks or processes that have already demonstrated their effectiveness. Biofeedback and behavior modification used in the behavioral and emotional realms are examples of analytic therapies which focus on specific emotional and behavioral processes and seek to modify them. FPA affords similar therapeutic potential in treatment of neurocognitive processing of school learning materials.

During the last century scientific progress in understanding how a specific human functions has been delimited as we explored the data compression model. With the burgeoning of neural science, and genetics, and the move toward more analytic assessment models the 21st century will be noted known for increased accuracy in understanding the individual human condition, sharper diagnoses, and the development of individual specific, effective treatments.

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